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ABSTRACT

Two experiments on the processing of lexical ambiguities in spoken prose were conducted using college students as subjects. The studies focused on noun-noun ambiguities, e.g. "straw" and "organ." The experiments utilized a variable stimulus onset asynchrony priming paradigm in which an auditory stimulus is followed at a variable interval (either 0 or 200 milliseconds) by a target word related to one meaning of the ambiguous word. For example, "Although the farmer bought the straw..." would be followed by "hay" or "sip." In the first experiment, with ambiguous words appearing in contexts that did not favor either reading, subjects accessed multiple readings or meanings at one millisecond but retained only a single reading 200 milliseconds later. In the second experiment, with ambiguous words appearing in contexts that provided semantic information relevant to only one reading, listeners accessed only a single reading at both stimulus onsets. The results suggest that selective access will occur for this class of ambiguous words when a word in the context primes one reading of a subsequent ambiguous word. (Author/MKM)

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Technical Report No. 164

THE TIME COURSE OF LEXICAL AMBIGUITY RESOLUTION IN CONTEXT

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Abstract

Two experiments on the processing of noun-noun ambiguities (e.g., STRAW, ORGAN) in spoken prose are reported. The experiments utilize a variable stimulus onset asynchrony (SOA) priming paradigm in which an auditory stimulus (e.g., "Although the farmer bought the straw . . .") is followed at a variable interval (either 0 or 200 msec) by a target word related to one reading of the ambiguous word (HAY, SIP). In Experiment 1, with ambiguous words appearing in contexts which did not favor either reading, subjects accessed multiple readings at 1 msec SOA but retained only a single reading 200 msec later. In Experiment 2, with ambiguous words appearing in contexts which provided semantic information relevant to only one reading, listeners accessed only a single reading at both SOAs. The results suggest that selective access will occur for this class of ambiguous words when a word in the context primes one reading of a subsequent ambiguous word.

The Time Course of Lexical Ambiguity Resolution in Context

Lexical ambiguity is one of the most extensively researched topics in the study of language comprehension (for reviews, see Clark & Clark, 1977; Fodor, Bever, & Garrett, 1974; Foss & Hakes, 1978; Seidenberg, 1979). Interest in lexical ambiguity derives from several sources. First, it is a linguistic universal (Greenberg, 1963) and ubiquitous in languages such as English; thus, determining how listeners and readers arrive at the contextually appropriate reading of a word with multiple meanings poses a problem for theories of language comprehension. Second, if the processes involved in ambiguity resolution are also involved in the comprehension of nonambiguous prose, studies of ambiguity may reveal general properties of the language processing system. Finally, lexical ambiguity presents an interesting paradox. Ambiguous words would seem to pose a more complex processing task than unambiguous words, yet they rarely are noticed or disrupt processing.

Previous research has been interpreted as supporting seemingly incompatible models of ambiguity resolution, in particular, models of <u>selective</u> vs. <u>multiple</u> access of meaning. According to the selective access model, listeners and readers are assumed to be guided by the context to the single contextually appropriate meaning of a homonymous word such as ORGAN or WATCH. On hearing a sentence such as (1), the perceiver is assumed to access only the reading of WATCH associated with timekeeping, and no other:

(1) John dropped his watch.

In contrast, the multiple access model maintains that the listener or reader accesses all of the common readings of the ambiguous word, and then selects the appropriate one on the basis of information provided by the linguistic and extralinguistic contexts and knowledge of the world. Swinney and Hakes (1976), Mehler, Segui, and Carey (1978), Oden and Spira (Note 1), and others obtained data supporting the selective access hypothesis; Foss and Jenkins (1973), Conrad (1974), Cairns and Kamerman (1975), Holmes, Arwas, and Garrett (1977), and Swinney (1979) obtained data supporting multiple access.

These apparent inconsistencies may be due to several factors. One is that researchers may have examined several classes of ambiguous words which are processed differently. These classes derive from the varying structural relations among the component readings of ambiguous words. The meanings may be semantically distinct (e.g., the "body part" and "musical instrument" readings of ORGAN) or semantically related (e.g., the senses of THROW in the expressions to throw a baseball and to throw a boxing match). This dimension underlies traditional distinctions between systematic and unsystematic ambiguities (Rubenstein, Garfield, & Millikan, 1970) and between homonymy and polysemy (Lyons, 1977). The component readings of ambiguous words also differ in relative frequency or typicality (Forster & Bednall, 1976; Hogaboam & Perfetti, 1975). For example, the two primary meanings of ORGAN are used approximately equally often; PEN, however, has two primary meanings, one of which (related to writing) is used more often than the other (related to pigs).

Ambiguous words also differ in terms of the grammatical categories into which the component readings fall. The component readings of ROSE are a noun and a verb, while the readings of ARTICLE are both nouns. Although the readings of a word may fall into other classes (e.g., FAST, which is adjective-noun), the noun-noun and noun-verb classes are the largest. These syntactic differences have important implications. The syntactic structure of the context typically is compatible with only one reading of a noun-verb ambiguity (as in (1)); assigning the alternate reading yields an ungrammatical, uninterpretable utterance. In general, syntax does not constrain noun-noun ambiguities in this way; a reading disfavored by the context (e.g., the "musical instrument" reading of ORGAN in (2)) yields an implausible but not ungrammatical or uninterpretable utterance. This fact is frequently exploited for humorous purposes (e.g., (3)):

(2) The surgeons removed Henry's damaged organ.

(3) The criminal received a long, hard sentence, and then he parsed it.

These structural variables presumably affect the representation of ambiguous words in memory, and hence, their access. It follows that experiments that examined different classes of ambiguous words might show different outcomes. Unfortunately, it is difficult to evaluate existing studies with respect to this variable, since the complete stimulus materials are rarely provided.

Some of the inconsistent findings in the ambiguity literature may derive from methodological problems associated with the phoneme monitoring task used in several studies (Cairns & Kamerman, 1975; Foss, 1970; Foss & Jenkins, 1973; Swinney & Hakes, 1976). Mehler et al. (1978) argued that phoneme monitoring latencies are dependent upon the length and frequency of the word preceding the target, factors which were not controlled in these studies. With these controls, Mehler et al. found no differences in phoneme monitoring latencies following ambiguous words compared with unambiguous controls, which they interpreted as evidence for selective access (see also Newman & Dell, 1978). However, interpretation of the Mehler et al. results is itself ambiguous, since there is no independent evidence that phoneme monitoring is sensitive to the processes involved in ambiguity resolution. Although Swinney & Hakes (1976) found evidence for selective access using the phoneme-monitoring task, Swinney (1979) failed to replicate these results using the lexical decision task.

Tanenhaus, Leiman, and Seidenberg (1979) noted another methodological problem associated with lexical ambiguity research. In most experiments, the subject's performance is monitored at a single point in time. However, lexical ambiguity resolution may involve several rapid processing stages, and the availability of alternate readings may vary as a function of time. As a consequence, experiments that sample at only one point in time may result in a partial or even misleading picture of the ambiguity resolution process.

The study by Tanenhaus et al. (1979) demonstrates the importance of studying the temporal parameters of ambiguity resolution. They examined the processing of noun-verb ambiguities such as ROSE and TIRE using a variable stimulus onset asynchrony (SOA) priming paradigm drawn from semantic memory research (Meyer & Schvaneveldt, 1971; Neely, 1977; Warren, 1977). Subjects heard sentences such as (4-5) followed by the presentation of a single word on a screen.

(4) Harry dropped the rose.

(5) John began to tire.

Their task was to read the target aloud. Targets were either related to the meaning of the ambiguous word biased by the context (e.g., FLOWER in (4)) or related to the alternate, unbiased reading (e.g., WHEEL in (5)). Each target also appeared with an unambiguous control sentence, which matched the ambiguous version except for the substitution of an unambiguous word in the final position (e.g., "John began to laugh."). Targets were always unrelated to these control stimuli. In these respects, the design was similar to that used by Conrad (1974). The critical difference was the introduction of the variable stimulus onset asynchrony manipulation. Targets appeared either 0, 200, or 600 msec after the ambiguous word.

Following Conrad, the logic of the experiment was that if listeners have access to a particular meaning of an ambiguous word at a particular SOA, latencies to read a word related to that meaning should show facilitation (faster reaction times) compared to unrelated controls, a priming effect similar to that of Meyer and Schvaneveldt (1971) and others. If listeners only accessed the single contextually appropriate reading, facilitation should have occurred only for the target related to that meaning. Latencies to the target related to the unbiased, unaccessed meaning should have been longer and equivalent to those for controls. If, however, listeners accessed both meanings of an ambiguity, there should have been approximately equal amounts of facilitation to both related targets.

The results indicated that target-naming latencies depended not only on whether the target word was related to the meaning of the ambiguous word biased by the context, but also on the latency at which the target word appeared. At the 0 msec SOA, facilitation obtained to target words related to both the contextually appropriate and inappropriate readings. At 200 and 600 msec, however, facilitation obtained only when the target word was related to the contextually appropriate meaning of the ambiguity.

The results suggested that noun-verb ambiguities with multiple common readings are resolved in a two-stage process. Multiple readings are initially accessed, followed by the selection of one reading and suppression of the alternative within 200 msec. Note that in effect, the experiment provided evidence for both multiple access (at 0 msec) and "selective" access (at 200 and 600 msec). Examining the availability of alternate readings at only a single point in time would have yielded misleading results.

The Tanenhaus et al. (1979) experiment demonstrated that the variable SOA methodology could be extended to the study of natural language processing. It suggested that, for at least some classes of ambiguities, resolution can be viewed as a multiple-stage process, and it showed that syntactic information alone could permit the listener to select a single reading. However, some classes of ambiguities cannot be resolved in this way. In particular, noun-noun ambiguities present a problem because the syntactic information which permitted selection of the appropriate reading of the noun-verb ambiguities is neutral with respect to competing alternatives. For this reason, it seemed likely that noun-noun ambiguities would be resolved by other means.

Clearly, this process may utilize semantic information provided by the context; that is, information derived from the meaning of the utterance rather than its syntactic structure. The present experiments were designed to determine whether semantic information would lead the listener to restrict lexical access to a single reading on-line, or whether, as in the case of noun-verb ambiguities, it would merely permit selection of a single reading following multiple access.

A second goal of the experiments was to evaluate the role of clausal structure in ambiguity resolution. Bever, Garrett, and Hurtig (1973) hypothesized that listeners access multiple meanings of ambiguous items and then select one at a major clause boundary. It follows that if a subject performs a standard psycholinguistic task <u>after</u> encountering such an ambiguity but <u>prior</u> to a clause break, evidence for multiple readings should be found. If the task is performed after completion of the clause containing the ambiguity, only one reading should be available. Experiments by Bever et al. supported this model with respect to deep and surface structure ambiguities, but were equivocal regarding lexical ambiguities. As the failure to find any difference in this condition might have derived from several sources, it was thought that the effects of clausal structure should be tested again. Thus, stimuli appeared in both complete and incomplete clause versions. As Marslen-Wilson, Tyler, and Seidenberg (1978) and Tanenhaus and Carroll (1978) have demonstrated that standard clausal processing effects occur only for clauses with explicit subjects and objects, only complete-clause stimuli of this type were included in order to provide the strongest possible test of the clausal model.

Experiment 1

This experiment investigated the processing of noun-noun ambiguities in contexts where neither semantic nor syntactic information favored one of the alternate readings. In a technical sense, the stimuli were vague and thus perhaps atypical. However, they provide the basis for comparisons to both the Tanenhaus et al. (1979) experiment, in which only biasing syntactic information was provided, and to Experiment 2, in which only biasing semantic information was provided. In addition, the test stimuli were embedded in a long list of unambiguous filler stimuli. Thus, subjects were neither informed of the occurrence of ambiguous stimuli, nor led to expect them.

Method

Subjects. Forty-eight students from Columbia University undergraduate psychology courses participated in fulfillment of a course requirement.

Stimulus material, and design. Twenty-four noun-noun ambiguities were selected which fit the following constraints: each word possesses two primary readings that are nouns; the component meanings are semantically distinct (unsystematic); both readings are common and used approximately equally often. These were placed in subordinate clauses such as those in Table 1. Each ambiguous word appeared in two clauses which were semantically and

Insert Table 1 about here

syntactically neutral with respect to the alternate readings. Clauses were either grammatically complete or incomplete. In half the stimuli, the incomplete clause was formed by including a verb which required an additional grammatical element. In the Table 1 example, the verb BUYS requires only a direct object, while the verb PUTS requires both a direct object and a locative. Hence, If John buys the straw forms a complete clause, while If John puts the straw does not. Incomplete clauses were also formed by introducing an embedded clause, e.g., Although Mary is aware that gin . . . .

Unambiguous control stimuli were formed by replacing the ambiguous word with words related to its alternate readings. The word STRAW, for example, was replaced with the unambiguous words WHEAT and SODA. Control words were closely matched to the ambiguous words in length, number of syllables, and Kučera and Francis (1967) frequency. There were two controls for each complete and incomplete ambiguous clause, yielding six clauses in a paradigm. Each of these clauses was paired with two target words related to the alternate readings. For example, HAY and SIP were the targets for STRAW. Each target was semantically related to one unambiguous control but not the other. That is, HAY is related to the unambiguous control WHEAT but not SODA; the opposite is true of SIP. Targets were also closely matched for length, number of syllables, and frequency. Crossing the six clauses with two targets yielded 12 clause-target combinations in a paradigm. There were 24 paradigms, yielding a total of 288 test stimuli.

The experimental design included the following conditions: (a) Related Ambiguous--clause ends in an ambiguous word, target is related to one of its meanings; (b) Related Unambiguous--clause ends in an unambiguous word, target is related to its meaning; (c) Unrelated Unambiguous--clause ends in an unambiguous word, target is unrelated to its meaning. This design, especially the use of two unambiguous controls, was motivated by the following considerations. Consider first the two unambiguous conditions. Latencies to read targets in the Related Unambiguous condition should be faster than those in the Unrelated Unambiguous condition, due to priming in the former condition, but not in the latter. If multiple readings of an ambiguous word are available at a given SOA, the word should prime both of its targets. Thus, the order of naming latencies should be:

Related Ambiguous = Related Unambiguous < Unrelated Unambiguous.

If only a single reading of each ambiguity is available at a particular SOA (either because selective access has occurred, or because one reading has been suppressed), the ambiguous word will prime only one target. If each meaning is accessed approximately equally often, reaction time in the Related Ambiguous condition will be composed of two parts, a fast component related to the priming that occurs to targets related to the accessed readings, and a slower component due to targets associated with the unaccessed meanings. This suggests that the orderings of reaction times should be:

Related Unabmiguous < Related Ambiguous < Unrelated Unambiguous.

If all subjects have only a single reading available at a given SOA for each ambiguous stimulus, reaction times in the Realted Ambiguous condition should fall midway between those in the two unambiguous conditions, ignoring experimental error. Thus, the availability of one or more readings at a given SOA is tracked by comparin reaction times in the ambiguous condition to those in both of the unambiguous controls. The Related Unambiguous control is required because the order Related Ambiguous $<$ Unrelated Ambiguous is predicted under both selective and multiple access.

The stimuli were apportioned into 12 versions. Each version contained one clause-target combination from each of the 24 paradigms. Each subject received only one version and thus did not encounter more than one stimulus from a paradigm. This design was intended to decrease the likelihood that the subjects would be cued into the ambiguity variable, which might lead them to access meanings that would otherwise have gone unnoticed. The stimulus items in a paradigm were randomly assigned to the 12 versions with the only other requirement being that two items from each of the 12 clause-target combinations in Table 1 be assigned to each version.

Each version consisted of 24 test sentences, eight each from the Related Ambiguous, Related Unambiguous, and Unrelated Unambiguous conditions. Half of the stimuli in each condition were complete clauses and half incomplete clauses. There also were 52 unambiguous filler stimuli, both complete and incomplete sentences, included in order to reduce the probability that subjects would become aware of the ambiguity manipulation. Half were followed by unrelated targets and half by related targets. These stimuli, which were identical in all 12 versions, varied in length from 2 to 17 words in order to prevent subjects from being able to predict occurrence of the target word. The order of test and filler stimuli was quasi-random; the only constraints were that no more than two test items occurred in a row and the first two items were fillers. There were also eight unambiguous practice items of varying lengths, for a total of 84 trials per subject.

The test and filler items were recorded on one channel of a stereo tape. They were read in normal intonation, which differed for the complete and incomplete versions. Approximately 10 secs elapsed between stimuli. A 500 Hz timing tone which coincided with the offset of the stimulus was recorded on the other channel. Placement of the timing tone was accomplished by running the recording tape slowly across the single head of a Sony TC-277 tape recorder. The target words were typed on translucent acetate material which was mounted on 2 x 2 inch slides.

Procedure. Subjects were randomly assigned to one SOA-version combination. Two subjects heard each version at each SOA. Subjects were instructed to listen to each sentence or sentence fragment and then read the target aloud as quickly as possible. They were told that the target would sometimes be related to the content of the immediately preceding utterance. Following target naming, they were to repeat back as much as they could remember from what was heard on the tape on that trial. This task was included to encourage subjects to attend to the recorded stimuli. Performance on the memory task was not systematically recorded.

The experimenter controlled the presentation of the stimuli from a room adjacent to the subject's. On each trial, a sentence or sentence fragment was heard binaurally over headphones, followed by visual presentation of a target word. Targets were projected into the subject room through a two-way mirror using a Kodak Carousel projector. Targets were projected onto the blank yellow wall in front of the subject. Target words subtended a visual angle of about 12 degrees horizontally and 8 degrees vertically. Presentation of the stimuli was controlled by electromechanical relay circuitry. The timing tone at the end of each sentence or sentence fragment was fed into a dual channel Lafayette model 6602A voice-operated relay. Closing the relay started a Scientific Prototype model 4005JA interval timer which controlled the SOA. This timer had a tested accuracy of ±5 msec. After the appropriate SOA (0 or 200 msec), the timer simultaneously closed an electromechanical relay which controlled a Lafayette VSI-E shutter opened for 1 sec, exposing the target slide. The subject stopped the clock by saying the target word into a Sony microphone connected to the second channel of the relay, which in turn was connected to the external stop on the Hunter timer. Stopping the Hunter timer closed an internal relay which advanced the slide tray. The experiment lasted about 25 minutes.

Results

Out of a possible 1152 reaction time scores, 24 (2.08%) were missing due to mechanical failure (the subject's response failed to stop the timer or the shutter was triggered early). These missing scores were distributed randomly across conditions, and were not replaced in the analyses. Only six subject errors occurred, less than 1% of all trials. These occurred when a subject read the wrong word or failed to respond.

The data were subjected to repeated measures analyses of variance with the factors SOA (0 or 200), type (Related Ambiguous, Related Unambiguous, Unrelated Unambiguous), and completeness (complete or incomplete clause). Subject and item analyses were performed for reasons outlined by Clark (1973). The subject analyses were performed on each subject's means for the various conditions (collapsing across the items that contributed to each mean). The item analyses were performed on the means for each item in each condition (collapsing across the subjects that contributed to each mean). Separate analyses were also performed on the data from each SOA.

In none of these analyses were there any main effects of clause completeness or any completeness interactions. Hence, only analyses which collapsed across this factor will be reported. Overall means are presented in Table 2. In analyses based on data from both SOAs, the effect of SOA was significant, $\min F'(1,24) = 4.43$, $p < .05$. The type effect was also significant, $\min F'(2,136) = 4.45$, $p < .01$, but the SOA by type interaction was not ($F < 1$ in both subject and item analyses).

In the analyses by individual SOAs, the type effect was significant at 0 msec, $\min F'(2,143) = 3.35$, $p < .05$, and at 200 msec by subjects, $F(2,46) = 11.66$, $p < .01$, but not by items, $F(2,94) = 2.18$, $p > .10$. At 0 msec SOA, the Related Ambiguous and Related Unambiguous conditions show almost equivalent levels of priming, 49 and 45 msec, respectively. Means in these conditions differ from that in the Unrelated Unambiguous condition, both $p < .01$ by the Newman-Keuls procedure; however, they do not differ from one another. At 200 msec SOA, facilitation in the Related Ambiguous condition averages 33 msec, while facilitation in the Related Unambiguous condition is 59 msec. Again the means in the Related conditions differ from those in the Unrelated Unambiguous condition by the Newman-Keuls procedure (Related Unambiguous, $p < .01$; Related Ambiguous, $p < .05$); however, they also differ from one another ($p < .05$). Thus, there was significant facilitation in both the

Insert Table 2 about here

Related Ambiguous and Related Unambiguous conditions at both SOAs; equal facilitation was seen in these conditions at 0 msec SOA, but there was significantly greater facilitation in the Related Unambiguous condition at 200 msec SOA.

Discussion

The results indicated that subjects initially accessed multiple readings, since at 0 msec SOA, priming effects in the Related Ambiguous and Related Unambiguous conditions were almost identical. The increase in naming latencies at the longer SOA in the Related Ambiguous condition would occur if priming occurred on approximately half the ambiguous trials. The latter outcome would itself result if only one reading were available for each ambiguous word at the longer SOA, and each reading was accessed almost equally often. Since multiple readings were available at the earlier SOA, it follows that suppression of all but a single reading occurred.

Since the same pattern of results obtained for both incomplete and complete clauses, the results do not provide any evidence that clausal structure affects lexical ambiguity resolution. The data suggest another possibility, namely, that ambiguity resolution is sensitive to limitations of time. Listeners selected a single reading even though the context failed to provide information which distinguished between alternatives. In principle, they had the option to wait until further information became available which distinguished between the readings. Furthermore, the design of the filler stimuli, many of which were complete sentences, insured that at the moment when the ambiguous word was heard, the listener had no way to know that such information would not be forthcoming. If the information processing system were oriented towards waiting until sufficient information became available to be able to assign a reading with a high probability of being correct, then one would have expected to see evidence for multiple readings at the 200 msec SOA. Instead, it appears that time limitations assumed overriding importance. It may be that carrying multiple readings longer than 200 msec --in effect, carrying them into the processing of the next word--places an extraordinary burden upon limited capacity processing resources.

These observations are highly speculative, of course. If they are correct, however, it should be possible to find other decoding operations that are similarly time-limited. A likely candidate is the identification of pronominal referents. If, as in ambiguity resolution, the context does not unequivocally isolate a single referent, the listener tentatively assigns a best guess. Reprocessing would be necessary in cases where initial misassignment occurs. The cost associated with reprocessing may be less than that associated with carrying multiple readings in parallel with the continuing signal. Again, however, this speculation rests upon further demonstrations that such processing decisions occur within a limited time frame.

Experiment 2

The question posed by this experiment is whether semantic information favoring one reading of a subsequent noun-noun ambiguity can permit exclusive access of that reading, or whether, as in the case of syntactic context and noun-verb ambiguities, biasing semantic information merely facilitates a subsequent decision stage in processing. The stimuli were clauses such as (6-8), similar to those used in the first experiment except for the addition of biasing information in the form of a word or phrase strongly related to one meaning of the ambiguous word. Each clause again appeared with targets related to the alternative readings (e.g., HAY and SIP); in all other respects the experimental design and procedure followed those used previously.

(6) Although the farmer bought the straw . . .

(7) Although the farmer bought the wheat . . .

(8) Although the farmer bought the soda . . .

A test of selective access is derived from this design as follows. Each ambiguous word should prime the target related to the contextually biased reading at 0 msec SOA. Thus, the target HAY will be primed following (6) and after (7), its related control, but not after (8), the unrelated control. Similarly, SIP should be primed following (8), its related control, but not after (7), its unrelated control. Selective access would be indicated if SIP were not primed following (6)--that is, if naming latencies in this condition were similar to those in the unrelated control (7)--and both were slower than those in the related control (8). If multiple access occurs, latencies to SIP following (6) should be equivalent to those in the related control (8), with both faster than unrelated controls (7). Note that these comparisons control for the effects of the context alone on target naming.

Method

Subjects. Forty-eight Columbia University undergraduates participated as part of a course requirement.

Stimulus materials. Thirty-six noun-noun ambiguities which obeyed the same constraints as in Experiment 1 were placed in complete and incomplete subordinate clauses which favored one reading. Clause completeness was again manipulated through verb structure and intonation. Unambiguous controls were again formed by replacing the ambiguous word with unambiguous words related to the alternate readings. Controls were closely matched to the ambiguous words in length, syllables, and frequency. Under this design, one unambiguous control word is related to the meaning of the ambiguous word biased by the context, and thus to the context itself. The other control word is related to the unbiased reading, and hence unrelated to the context. Each clause again appeared with two targets related to the alternate readings of the ambiguity; as with the control words, one target is related to the context and to the contextually biased reading of the ambiguity; the other target is related to the unbiased reading and hence unrelated to the context. This yielded 12 clause-target combinations in a paradigm. A sample is presented in Table 3.

Insert Table 3 about here

The 12 conditions can be conceptualized as follows. The stimuli are derived from three factors: type, which refers to the relation between the sentence-final word and the target independent of the context; target; and clause completeness. Type has three levels, Related Ambiguous, Related Unambiguous, and Unrelated Unambiguous. The target factor has two levels, Related (to the context and the biased reading) and Unrelated (to the context and the biased reading). The completeness factor consists of Complete and Incomplete clauses. All of these factors are crossed with each other and with SOA (0 and 200 msec). There were 36 experimental paradigms, yielding a total of 432 stimuli. These were again apportioned into 12 versions. Each order contained one stimulus from each of the 36 paradigms and three from each of the 12 conditions. There were also 36 filler stimuli, unambiguous complete and incomplete sentences varying in length from 2 to 15 words. These were always followed by unrelated targets. The order of stimuli was again quasi-random, with the only constraints being that the first four were fillers and no more than two test stimuli appeared in a row. There were also eight unambiguous practice items of varying lengths, for a total of 80 trials per subject.

The test and filler items were recorded on one channel of a stereo tape. As before, they were read with normal intonation, which differed from the complete and incomplete versions. About 10 sec elapsed between stimuli. A 500 Hz timing tone which coincided with the offset of the clause was recorded on the other channel. Timing tones were placed using the method described previously. Targets were typed on translucent acetate and mounted on 2 x 2 slides.

<u>Procedure</u>. All aspects of the procedure were identical to those used in Experiment 1. Two subjects heard each version at each SOA. They performed the same tasks, naming the target and repeating back the auditory stimulus.

The experimental apparatus was identical to that used previously, except that an improperly grounded dual channel relay was replaced with a Scientific Prototype Audio Threshold Detection relay model 761-G and a Grayson Stadler model E7300A-1 relay, and the microphone that registered the subject's response was changed to a Sony F-98. The experiment lasted about 35 minutes.

Results and Discussion

Of the 1728 possible scores, 29 were missing (1.7%), 6 due to subject errors, and 23 due to mechanical failures. The missing scores were distributed randomly across conditions and were not replaced in the analyses. The means for each condition are presented in Table 4. Following the procedure used in Experiment 1, subject and item analyses of variance were performed on data from both stimulus onset asynchronies, and separately on the

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Insert Table 4 about here

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individual SOA data. The factors were SOA (0 and 200), type (Related Ambiguous, Related Unambiguous, and Unrelated Unambiguous), target (Related and Unrelated), and completeness (Complete and Incomplete clauses). The type, target, and completeness factors were crossed with subjects, which were nested within SOA. Subject and item means were derived as before.

In the analyses on data from both SOAs, the main effect of SOA was highly significant by items, $F(1,35) = 210.62$, $p < .001$, but not by subjects, $F(1,46) = 2.67$, $p > .10$. As in Experiment 1, this reflects the fact that SOA is analyzed as a within-units variable in the item analysis, but as a between-units variable in the subject analysis.

The main effect of type was significant, min$F'(2,68) = 3.70$, $p < .05$. The target factor was marginally significant by subjects, $F(1,46) = 3.60$, $p < .07$, but not by items ($F < 1$). The type by target interaction was significant by subjects, $F(2,92) = 4.87$, $p < .01$, but not by items ($F < 1$). Finally, the completeness variable was significant in both the subject and item analyses, min$F'(1,80) = 8.99$, $p < .01$. The other interactions did not approach significance.

The analyses by individual SOAs also showed this general pattern. At SOA 0 msec, the effect of type was significant by subjects, $F(2,46) = 3.21$, $p < .05$, and by items, $F(2,70) = 3.49$, $p < .05$. The effect of completeness was also significant, min$F'(1,51) = 5.26$, $p < .05$. The only other effect to reach significance at 0 msec was the type by target interaction in the subject analysis, $F(2,46) = 3.47$, $p < .05$.

At 200 msec SOA, the type effect was significant by subjects and marginally by items, $F(2,46) = 11.21$, $p < .001$, and $F(2,70) = 2.63$, $.05 < p < .10$, respectively. The effect of completeness was again significant, min$F'(1,57) = 4.02$, $p < .05$. The target factor reached significance in the subject analysis, $F(1,23) = 4.43$, $p < .05$. No other main effects or interactions were significant in either subject or item analyses.

The main effect of SOA is due to longer naming latencies in every condition at 200 msec SOA, replicating the effect observed in Experiment 1. This factor again did not interact with any other. The type effect and type by target interaction are interpretable as follows. Both the unambiguous conditions show the same pattern for both types of targets: Related

Unambiguous latencies are faster than the Unrelated Unambiguous latencies, due to priming. In the ambiguous conditions, however, reaction times depend on the type of target. With targets related to the contextually biased readings of the ambiguous words, both Related Ambiguous and Related Unambiguous conditions show faster latencies than the Unrelated Unambiguous condition. With targets related to the alternate, unbiased readings, only the Related Unambiguous condition shows faster latencies than those in the Unrelated Unambiguous condition; those in the Related Ambiguous condition are now longer than in the Related Ambiguous condition. This suggests that priming occurred in the Related Ambiguous condition only for targets related to the contextually biased readings. The interaction is relatively weak at least in part because only one of the three conditions (Related Ambiguous) is affected by target type in this way.

In contrast to the results of Experiment 1, there was a strong main effect of clause type, with latencies to the complete clauses faster than those in matched incomplete clauses. The appearance of this effect only in Experiment 2 is somewhat puzzling. There is one difference between the stimuli in the two experiments which may account for this pattern. Clauses in Experiment 1 were constructed so as to be neutral with respect to alternate readings. Their subjects were frequently names of unidentified persons. In Experiment 2, subjects were chosen so as to be biased toward one reading of the ambiguous word; hence, they were more specified noun phrases such as <u>the farmer</u> or <u>the plumber</u>. It is possible that clause effects appear only with subjects of the latter sort.

Since the clause effect was highly consistent across conditions and did not interact with any other factor, means were calculated for the six conditions at each SOA which result from collapsing across this variable. These are presented in Figure 1. In the analyses of variance on data from both SOAs, the main effect of SOA was significant by items, $F(1,35) = 220.09$, $p < .001$, but not by subjects, $F(1,46) = 2.79$, $p > .10$. The type effect was significant, $\min F'(2,122) = 3.31$, $p < .05$. The type by target interaction was significant in the subject analysis, $F(2,92) = 4.01$, $p < .05$, but not in the item analysis, ($F < 1$). The main effects of target and the remaining interactions did not approach significance in either subject or item analyses.

In the 0 msec analyses, there were main effects of type by subject, $F(2,46) = 3.22$, $p < .05$, and marginally by item, $F(2,70) = 2.56$, $.05 < p < .10$. The main effect of target was not significant by subjects or items, both $F < 1$; however, there was a type by target interaction in the subject analysis, $F(2,46) = 3.00$, $p < .05$.

In the 200 msec analyses, there was a strong main effect of type in the subject analysis, $F(2,46) = 10.40$, $p < .001$, and a marginal effect by items, $F(2.70) = 2.52$, $.05 < p < .10$. The target effect was marginally significant by subjects, $F(1,23) = 3.72$, $.05 < p < .10$, but not by item, $F < 1$. The type by target interaction was not significant in either subject or item analysis.

Insert Figure 1 about here

As Figure 1 indicates, when the target is related to the context, there is almost equivalent priming in the Related Ambiguous and Related Unambiguous conditions relative to the Unrelated Unambiguous condition at each SOA. This pattern suggests that the reading of each ambiguous word r lated to the biasing context was assigned immediately. With targets related to the unbiased reading, latencies in both the Related Ambiguous and Unrelated Unambiguous conditions are longer than those in the Related Unambiguous condition at both SOAs. At 0 msec, latencies in the Related Ambiguous condition are 9 msec longer than those in Unrelated Unambiguous controls; at 200 msec, they are 11 msec faster than unrelated controls. Neither of these differences approaches significance. Thus, there is priming in the Related Ambiguous condition only with targets related to the biased readings.

While there is almost equal priming in the Related Ambiguous and Related Unambiguous conditions at both SOAs when targets are related to the contextually biased meanings, there is more facilitation in the Related Unambiguous condition than in the Related Ambiguous condition at both SOAs when the targets are related to the unbiased readings. This is also indicated by significant _t_-tests on facilitation scores in these two conditions derived from subject means; at 0 msec SOA, $t(23) = 2.27$, $p < .05$; at 200 msec, $t(23) = 4.02$, $p < .01$.

The results suggest that the biasing sementic contexts permitted selective access of the contextually appropriate reading to occur. Ambiguous words primed targets related to the reading biased by the context at 0 msec, but did not prime targets related to the unbiased readings. Unlike in Experiment 1, there was evidence of a clause-boundary effect--longer reaction times to incomplete clauses--but the pattern of results across conditions was similar for both complete and incomplete clauses. As in Experiment 1, the reaction times were longer at 200 msec SOA than at 0 msec SOA.

In contrast to the previous experiments, in which multiple access was observed immediately following ambiguous words, selective access occurred in Experiment 2. Although the syntactic information provided by the contexts in the Tanenhaus et al. (1979) noun-verb experiment was utilized in a decision stage subsequent to initial meaning access, the semantic information provided by the contexts in this experiment was utilized immediately. Any explanation of these results must postulate a process which has an effect on the initial access of meaning.

One simple possibility is that the semantic context primed one reading of the noun-noun ambiguity before it was encountered. While the readings were initially at approximately equivalent resting levels of activation, priming radically altered the relative activation levels. The readings were then accessed in order of relative activation level; at 0 msec SOA, only the primed reading had been accessed, and it was integrated with the context on line. Once a reading was successfully assigned, access to the alternative was blocked.

To be more concrete, consider the following example. When DOCTOR is recognized in sentence (9), a location is assumed to be activated in the semantic memory network where such information is stored (Collins & Loftus, 1975).

(9) When the doctor began to remove Henry's damaged organ, . . .

Activation subsequently spreads through the network to the nodes of related words. This has the effect of lowering their detection thresholds, so that if one of them is subsequently encountered (e.g., NURSE), it is recognized faster than a semantically unrelated word. Under this model, selective access is predicated with two further assumptions, namely, (a) that the semantically distinct component readings of ambiguous words are stored at separate locations in the memory network, and (b) that the readings of an ambiguous word are checked against the context in an order determined by their relative levels of activation. The first assumption is implicit in the Collins and Loftus model, in which two interconnected memory networks are proposed, one representing semantic information, and the other representing orthographic and phonological information (see also Warren, Warren, Green, & Bresnick, 1978). Thus, the two readings of ORGAN would have separate locations in the semantic network, but a single location in the lexical network. When DOCTOR is recognized, activation spreads to one node of ORGAN, but not to the other. The second assumption follows from Hogaboam and Perfetti (1975) and Krauss and Strickler (reported in Krauss, 1979), and from research relating word recognition time to frequency (e.g., Berry, 1971). When ORGAN is subsequently encountered in the sentence, the primed reading is accessed, the listener attempts to integrate it with the context and succeeds. Note that this process would be impossible in the case of noun-verb ambiguities in syntactic contexts, where the context would, in effect, have to prime not a class of semantically related words, but rather, all of the words in a particular grammatical class (e.g., all the nouns). Aside from the fact that [illegible]r of the momeory networks in the Collins and Loftus (1975) model is organized in terms of syntactic function, this notion is unacceptable because it implies activation of a potentially infinite class of items.

In arguing for the priming explanation, it should also be noted that most of the stimuli in Experiment 2 were adapted from the neutral stimuli in Experiment 1. In converting the stimuli, noun phrases which were highly semantically or associatively related to one reading of each ambiguous word were introduced. As such, they were highly likely to produce priming. The priming interpretation is also supported by the similarity of these results to those of Schvaneveldt, Meyer, and Becker (1976), who used only single-word stimuli. Their stimuli are much like those that would result if the stimuli from the present experiment were converted into triples which contained a context word, an ambiguous or control word, and a target (e.g., FARMER-STRAW-SODA from these stimuli would be similar to their RIVER-BANK-MONEY condition). Schveneveldt et al. also did not observe facilitation (in the lexical decision task) in this condition. Thus, an outcome similar to the one observed in Experiment 2 occurred in contexts where only lexical information was provided.

While priming is a likely explanation for the present results, cases such as (10-11) appear to require another mechanism.

(10) Henry bought some straw.

(11) The man walked the deck.

In (10) the correct reading of STRAW is indicated not because a word in the context is highly semantically or associatively realted to one reading, but because of one's knowledge that on one reading, STRAW is a mass noun, while on the other, it is a count noun. If the sentence is grammatical, the mass noun reading must be assigned. In (11) the correct reading of DECK is dictated by pragmatic constraints, specifically, one's knowledge that the surface of a boat is more suitable for walking than a pack of playing cards. In these cases, noun-noun ambiguities appear to be resolved without priming.

Tanenhaus, Seidenberg, Leiman, and Bienkowski (Note 2) have recently investigated such contexts using the priming methodology and observed multiple access followed by selection of the contextually appropriate reading. Again, the difference between this pattern of results and that in Experiment 2 is explained by the existence of priming only in the latter case.

These results suggest that contexts can affect two distinct stages of the resolution process. Priming contexts affect whether one or more readings are initially accessed. Syntactic and conceptual contexts (where the latter includes listener-generated pragmatic information and nonpriming semantic information) affect a subsequent integration stage.

The results of this experiment provide relatively decisive evidence that some contexts permit selective access to occur, using an experimental procedure that is not subject to the problems associated with tasks such as phoneme monitoring. Three aspects of the data deserve further comment. The first is that the relatively weak item effects call into question whether the results will generalize beyond the specific sample of items tested. As noted above, the weakness of the item analyses is in part a function of the experimental design, which was utilized in order to insure that subjects would not become aware of the ambiguity variable. That the results will generalize beyond this sample is suggested by the fact that they have recently been replicated using a different sample of ambiguous words and sentences (Tanenhaus et al., Note 2).

The second problematical aspect of the data is the systematic increase in naming latencies at the longer SOA. This stands in contrast to studies of word recognition in which naming and lexical decision latencies are inversely related to SOA (e.g., Neely, 1977; Posner & Snyder, 1975). The simplest interpretation is that these increases are due to some nonobvious aspect of the experimental procedure or apparatus. The longer reaction times may derive from less trivial sources, however. The experiments which show a decrease in reaction time with increasing SOA are ones in which both the priming and target stimuli were individual lexical items, while in the present experiments, the priming stimulus was a sentence fragment. The increase at the longer SOA could be due to continued processing associated with the priming clause, e.g., identification of major constituents, organization of information into propositional units, generation of inferences, and other processes. This issue can only be resolved through direct comparisons of sentential and lexical primes.

Finally, the emergence of a clause effect only in Experiment 2 calls into question whether a fair evaluation of this variable has been provided. The experiments provide no positive evidence that lexical ambiguity resolution is sensitive to clausal structure, however.

General Discussion

The experiments suggest that the contradictions in the existing lexical ambiguity literature may be more illusory than they at first appear, since both selective and multiple access have been observed using a single methodology and tightly controlled materials. In the Tanenhaus et al. (1979)

experiment, multiple access was observed, followed by the selection of the contextually appropriate reading within 200 msec and suppression of the alternatives. Although syntax favored only one reading of each ambiguous word, this information did not permit initial access of a single reading. In Experiment 1, multiple access was seen for a different class of ambiguous words in truly neutral contexts, followed by selection of a single reading within 200 msec. This occurred despite the fact that the context did not decisively favor either reading. In Experiment 2, selective access was observed, with only the contextually appropriate reading available at both SOAs. It is clear that either selective or multiple access may occur depending on both the structure of the ambiguous lexical item and the structure of the context.

THe results are compatible with a model along the following lines. Lexical ambiguities are processed largely in the same manner as unambiguous words. Lexical information is represented in lexical and semantic networks of the sort proposed by Collins and Loftus (1975), which contain phonological, orthographic, and semantic information. Words are also coded in terms of their syntactic functions, and possibly in other ways as well (e.g., in terms of the case relations they may enter into). The semantically-distinct readings of an ambiguous word are represented at separate locations in the semantic network which are interconnected to a single node in the lexical network. The resting levels of activation at nodes in the semantic network reflect differences in frequency and recency of use. A word is recognized when both its lexical and semantic codes are activated. This process begins with a largely bottom-up analysis of the input code. Listeners may also use information in the context to facilitate analysis of the input code for a word (Marslen-Wilson & Welsh, 1978).

When the listener succeeds in identifying the sensory code for a word, activation spreads to the interconnected node(s) in the semantic network. In the case of an unambiguous word, activation spreads to a single node, and the word is recognized when the level of activation at that node exceeds some threshold value. The latency to recognize a word will depend on the difference between this threshold value and the resting level of activation. In general, high-frequency, recently used words will be recognized faster (but see Cairns & Foss, 1971).

In the case of an ambiguous word, activation spreads from a location in the lexical network to multiple nodes in the semantic network. Which meaning or meanings are recognized depends on the number of readings which pass threshold, and the order in which they do so. These events in turn depend on the relative resting levels of activation and the nature of the context.

Various outcomes fall out of these assumptions:

1. Selective access is the case in which the contextually appropriate reading passes threshold first because the resting level of activation associated with that reading is decisively higher than that associated with any alternate readings. This difference in activation level can occur for two reasons. First, the component readings may differ in frequency of use. There

may also be recency effects, with higher levels of activation associated with recently used word senses (Scarborough, Cortese, & Scarborough, 1977). Second, the resting level of activation associated with a word sense may be altered by priming. When a context word is recognized, activation spreads along the semantic memory network to the nodes of semantically related words. If one of these nodes includes the node for one of the readings of an ambiguous word that is subsequently encountered, activation will accumulate at that node, lowering its detection threshold. In effect, this will skew the relative levels of activation at the nodes of the alternate readings. A highly primed or frequent reading is accessed first, and the listener attempts to integrate it with the context. This will succeed if the most active reading is also the contextually appropraite one.

2. Garden-pathing on the lexical level is the case in which the most active reading is not contextually appropriate. This will occur when a word is used in an infrequent sense, or when the context primes the incorrect reading and it reaches a much higher level of activation than the contextually appropriate reading, as perhaps occurs in sentences such as, <u>The doctors played Henry's organ</u>. In such cases, reprocessing is necessary; the listener discards the inappropriate reading and actively searches for an alternate. This process will terminate when either (a) a contextually appropriate reading is found, or (b) all of the frequent readings stored in memory are exhausted. In the latter case, the listener may attempt to search for very low frequency readings, or seek more information from the speaker.

3. Multiple access is the case in which two readings pass threshold before initiation of the integration process. The activation of word senses is assumed to be an automatic capacity-free process (Neely, 1977), so that the activation of multiple meanings does not deplete limited capacity processing resources any more than access of a single reading. Thus, measures which are sensitive to processing load (e.g., phoneme monitoring) will not show any differences as a function of whether selective or multiple access has occurred. Multiple access will occur when either (a) the readings are at approximately equal levels of activation and the context does not prime one reading, or (b) the context primes a less frequent reading, bringing its level of activation up to that of the alternate reading(s). When multiple access occurs, two or more readings are passed to the contextual integration stage. The listener checks the semantic and syntactic information associated with the component readings against the demands of the context. This is the same process as that which occurs in the integration of unambiguous words, except that multiple alternatives must be evaluated. The details of this process are largely unknown. It is not known, for example, whether the readings are evaluated serially or in parallel, whether the process is exhaustive (all available readings checked against the context) or terminal (readings only checked until the appropriate one is found), or how different types of contextual constraints are weighted. When a contextually appropriate reading is finally selected, the alternative is suppressed. When the context does not decisively favor one reading, listeners nonetheless select one and suppress the alternative within about 200 msec. It appears that while the

initial access of multiple readings does not come at great cost to the processing system, retaining multiple readings does.

4. Once a meaning is assigned, activation of alternative readings is suppressed. This occurred following multiple access in the Tanenhaus et al. (1979) experiment and in Experiment 1; it occurred with selective access in Experiment 2.

To summarize the implications of the present experiments:

First, ambiguous words are coded in memory in terms of a number of characteristics which are exploited in the comprehension process. In particular, the syntactic properties of ambiguous words are critical. This syntactic information is not represented in any current model of the mental lexicon, however. The relative frequencies of the component readings are the other important structural factor. Holmes (1980) has recently suggested that meanings are evaluated in order of relative frequency, and further that only one reading is evaluated at a time. This implies that the processing system is sensitive to extremely small differences in frequency. More research is necessary in order to determine which differences in frequency affect access of meaning.[2]

Second, contexts operate in the ambiguity resolution process in two ways. Nonpriming contexts provide conceptual and syntactic information which drives the processes involved in the integration of both ambiguous and unabmiguous words. In cases where the contextually appropriate reading is accessed first, the integration process proceeds exactly as in the case of unambiguous words. In cases where the contextually appropriate reading is accessed first, the integration process proceeds exactly as in the case of unambiguous words. The only additional operation is the blocking of access to alternate readings once integration has succeeded. When multiple readings have been activated, these contexts permit the selection of a single reading; however, these contexts do not affect the readout of meanings from the mental lexicon. Thus, when two readings are at approximately equal levels of activation, multiple access will occur even if syntactic or conceptual information in the context favors only one reading. This is to say that the word recognition process yields a reading or readings to be evaluated against the constraints imposed by these types of contextual information. The only way for the context to affect the order in which readings are accessed is if there are direct connections in memory between words in the context and a component reading of the ambiguous word. This is the second way in which contexts can affect ambiguity resolution--that is, by priming, which was observed in Experiment 2.

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Footnotes

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[1]Only minF' statistics will be reported when they are significant; otherwise F statistics from both subject and item analyses will be reported. With the exception of the effects due to the between-subjects factor SOA, all of the reported effects are weaker in the item analyses than in the subject analyses. This is largely due to two factors, greater variability between subjects than between items, and the requirement that subjects see only one stimulus from a paradigm.

[2]This enterprise has been impeded by the lack of reliable data concerning the relative frequencies of occurrence for component readings. It will be facilitated greatly by the imminent appearance of M. F. Garrett's Kučera and Francis-type count for the readings of 300 ambiguous words.

Table 1

Conditions and Sample Stimuli, Experiment 1

Condition	Clause	Target
Related Ambiguous	If Joe buys (puts) the straw	HAY
	If Joe buys (puts) the straw	SIP
Related Unambiguous	If Joe buys (puts) the wheat	HAY
	If Joe buys (puts) the soda	SIP
Unrelated Unambiguous	If Joe buys (puts) the soda	HAY
	If Joe buys (puts) the wheat	SIP

Note: Clauses appeared in complete and incomplete versions. Verbs for the incomplete version are in parentheses.

Table 2

Mean Naming Latencies and Facilitation Scores, Experiment 1

Condition	0 msec SOA		200 msec SOA	
	Naming Latency	Facilitation	Naming Latency	Facilitation
Related Ambiguous	655 (24)	49	778 (19)	33
Unrelated Ambiguous	659 (22)	45	752 (22)	59
Unrelated Unambiguous	704 (23)	--	811 (21)	--

Note: Entries are in msec. Numbers in parentheses are standard errors.

Table 3

Conditions and Sample Stimuli, Experiment 2

Targets Related to Context and Biased Reading		
Condition	Stimulus	Target
Related Ambiguous	Although the farmer bought (put) the straw	HAY
Related Unambiguous	Although the farmer bought (put) the wheat	HAY
Unrelated Unambiguous	Although the farmer bought (put) the soda	HAY
Targets Unrelated to Context or Biased Reading		
Related Ambiguous	Although the farmer bought (put) the straw	SIP
Related Unambiguous	Although the farmer bought (put) the soda	SIP
Unrelated Unambiguous	Although the farmer bought (put) the wheat	SIP

Note: Clauses appeared in complete and incomplete versions. Verbs for the incomplete versions are in parentheses. Targets unrelated to biased reading were also related to unbiased reading.

Table 4

Mean Naming Latencies, Experiment 2

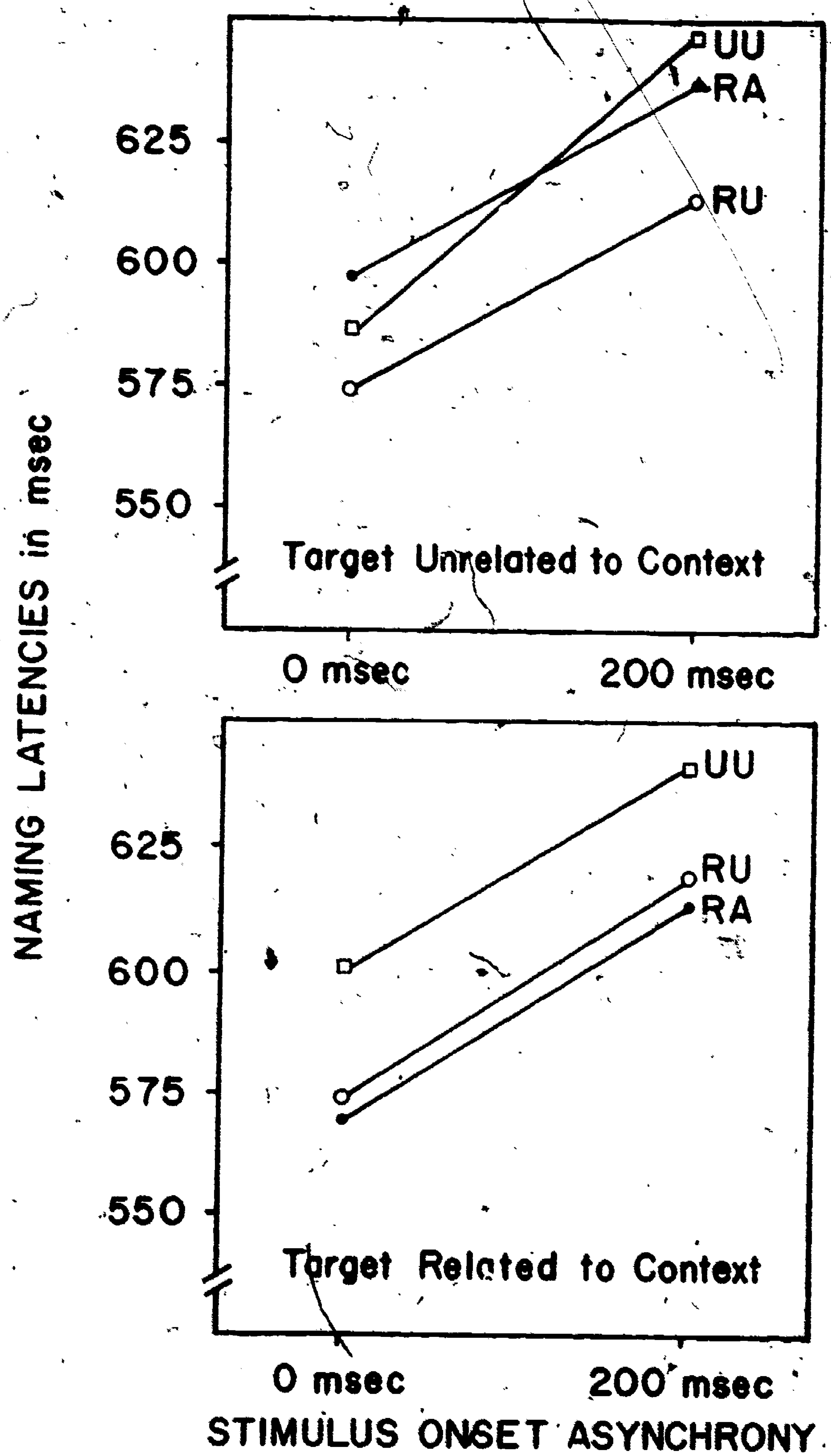
Condition	Complete	Incomplete	Sample Stimuli
Targets Related to Biased Reading			
0 msec SOA			
Related Ambiguous	554 (21)	586 (23)	farmer-straw-hay[a]
Related Unambiguous	569 (19)	578 (23)	farmer-wheat-hay
Unrelated Unambiguous	593 (20)	611 (27)	farmer-soda-hay
200 msec SOA			
Related Ambiguous	601 (22)	625 (26)	farmer-straw-hay
Related Unambiguous	601 (18)	635 (22)	farmer-wheat-hay
Unrelated Unambiguous	625 (21)	658 (22)	farmer-soda-hay
Targets Unrelated to Biased Reading			
0 msec SOA			
Related Ambiguous	582 (22)	608 (22)	farmer-straw-sip
Related Unambiguous	568 (23)	580 (22)	farmer-soda-sip
Unrelated Unambiguous	578 (20)	594 (19)	farmer-wheat-sip
200 msec SOA			
Related Ambiguous	635 (22)	638 (18)	farmer-straw-sip
Related Unambiguous	604 (19)	622 (21)	farmer-soda-sip
Unrelated Unambiguous	646 (22)	649 (22)	farmer-wheat-sip

Note: Entries are in msec. Numbers in parentheses are standard errors.

[a]The first word in each triple provides biasing contextual information; the second is the ambiguous or control word; the third is the target.

Figure Caption

Figure 1. Mean naming latencies that result from collapsing across completeness variable. UU = Unrelated Unambiguous, RA = Related Ambiguous, RU = Related Unambiguous. Targets related to the context were also related to the contextually-biased reading of the ambiguous word; targets unrelated to the context were related to the non-biased reading.


NAMING LATENCIES in msec
625
600
575
550
UU
RA
RU
Target Unrelated to Context
0 msec
200 msec
625
600
575
550
UU
RU
RA
Target Related to Context
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